Performance Analysis of CP-OFDM with Different fading channels with Energy Efficient Binary Power Control

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***Abstract*— The main idea between OFDM is, the so called, Multi Carrier Modulation (MCM) transmission technique. The performance is calculated in terms of Bit Error Rate (BER) versus the Signal to Noise Ratio (SNR). In this project we discuss the BER performance of the MIMO-OFDM system with two different equalizers (ZF and MMSE) for various modulation techniques i.e. BPSK, QPSK, QAM using multipath fading channels i.e. AWGN (Additive White Gaussian Noise), Rayleigh and Rician channel. The multicarrier modulation is employed, which gives advantages like inter symbol interference (ISI) reduction, high data rate, high reliability and better performance in multipath fading. The simulation results show that, with MMSE and ZF equalizers, the BER performance is better in MMSE equalizer. Further we analyze in different fading channels for various modulation techniques in both the equalizers. We explore the idea of optimizing the energy efficiency for MIMO-OFDM wireless communication systems while maintaining a given QoS demand.**

***Index Terms*— OFDM, ZF and MMSE Equalizer, Multipath fading channels, energy efficiency.**

I. Introduction

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor. The wireless communication system is composed of radio frequency (RF) blocks, intermediate frequency (IF) blocks and baseband (BB) blocks. Wireless operations permit services, such as long-range communications, that are impossible or impractical to implement with the use of wires[1].

Orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) [6]without complex equalization filters. In OFDM, the sub-carrier frequencies are chosen so that the sub-carriers are orthogonal to each other, meaning that cross-talk between the sub-channels is eliminated and inter-carrier guard bands are not required [1]. This greatly simplifies the design of both the transmitter and the receiver; unlike conventional FDM, a separate filter for each sub-channel is not required [2].

II. Problem Overview

It is observed that the channel capacity increases with the number of antenna added to the system due to the more diversity gain of Alamouti's code. The two main drawbacks of OFDM are the large dynamic range of the signals being transmitted and the sensitivity to frequency errors. The term cyclic prefix refers to the prefixing of a symbol with a repetition of the end. It preserves orthogonality between sub-carriers and allows the receiver to capture multipath energy more efficiently. Also, we estimate the channels with different fading channels and finally we calculate the binary power control using EPCBBER.

III. Previous Work

OFDM stands for Orthogonal Frequency Division Multiplexing. OFDM channel bandwidth is divided into multiple sub-channels to reduce ISI and frequency selective fading. Carrier centers are put on orthogonal [2][7] frequencies and subcarriers are spaced by 1/Ts.

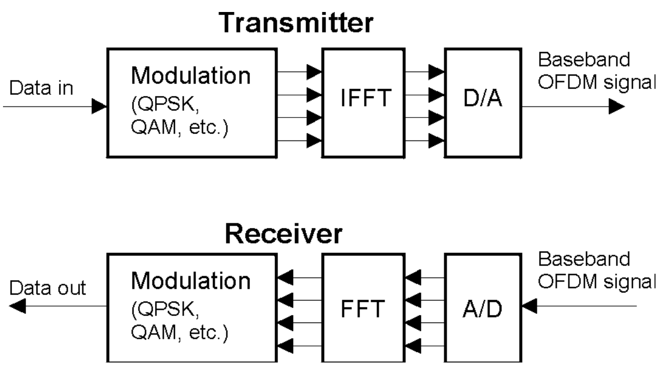

Fig.(1) Block Diagram of OFDM Transmitter and Receiver

N^{th} OFDM block is,

$$S_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} S_{n,k} \delta_k \left(1 - nT\right) \tag{1}$$

Transmitted signal for i^{th} OFDM signal is,

$$S_i(t)=\frac{1}{N}\sum_{k=0}^{N-1}X_i(k)e^{\frac{j2\pi}{NT_s}k(t-\alpha_i T_s)} \tag{2}$$

Received signal is,

$$S_n=\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1}S_k\exp\left(\frac{j2\pi kn}{N}\right) \tag{3}$$

IV. PROPOSED WORK

A. Basic System Model

Here, we will be estimating different channels using different modulation techniques [3][8].

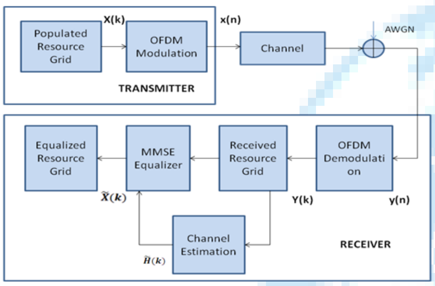

Fig.(2) Block Diagram for Channel Estimation

The set of sub channels enabled for transmission is denoted as *C*, which is expressed as,

$$CH_i=C, C=\{CH_i|1\le i\le N\} \tag{4}$$

where, CH_i is the sub channel *i*.

In this case, the relationship of P_{total} , $P_{\max\ total}$ and P_{mintotal} is described as follows,

$$P_{total} = P_{\max\ total} + P_{\mathrm{mintotal}} \tag{5}$$

$$P_{\max\ total} = M \times P_{\max} \tag{6}$$

$$P_{\min\ total} = (N - M) \times P_{\min} \tag{7}$$

B. Binary Power Calculations:

Based on the binary power control scheme, a power allocation criterion for energy efficiency optimization is derived under the total power constraint [4][9]. From a bit error rate (BER) point of view, a protection constraint is configured to guarantee the system QoS. With the aim of energy efficiency optimization under QoS guarantee in MIMO-OFDM wireless communication systems, an energy-efficient binary power control with BER constraint (EBPCB) algorithm is proposed based [10] on the power allocation criterion and QoS constraint. Simulations results demonstrate the energy efficiency improvement of EBPCB [5].

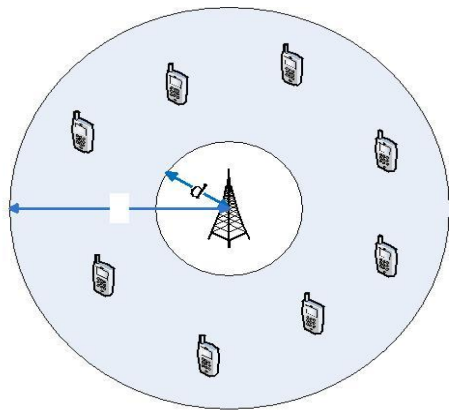

Fig.(3) System Model for MIMO OFDM

The minimum power transmission sub channel subset is,

$$C = \{CH_i|1 \le i \le N\} \tag{8}$$

Maximum power transmission sub channel subset is,

$$K_{p\max}^{M} = \phi \tag{9}$$

Minimum power transmission sub channel subset is,

$$K_{p\min}^{N-M} = \phi \tag{10}$$

When sub channel is assigned to maximum power transmission, then Pmax is given by,

$$P_{\max} = \frac{P_{\max\_total}}{M} \tag{11}$$

When sub channel is assigned to minimum power transmission, then Pmin is given by,

$$P_{\min} = \frac{P_{total} - P_{\max\_total}}{N - M} \tag{12}$$

V. RESULTS AND CONCLUSION

The performance of different modulation techniques with OFDM AWGN and Rayleigh fading distribution was evaluated. Graphical results show the improvement in BPSK with Rayleigh fading channel compared to its performance in AWGN channel. The graphical results prove that simulated BER of BPSK is same as that of theoretical BER of BPSK. The reported BER can be further reduced by using channel estimation or suitable diversity scheme.

But QAM is widely used rather than PSK because of the data modulated with amplitude as well as phase, while PSK only use the phase, if the signal is corrupted during the transmission, it still can be corrected by either amplitude or phase. In QPSK, as SNR increases, Probability of error decreases indicating that for high SNR error probability is very low.

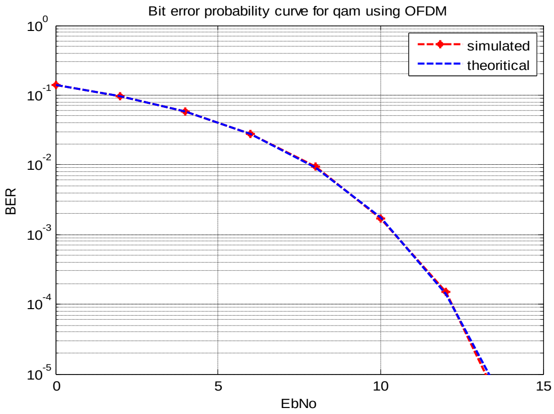

Fig.(4).BER probability for QAM

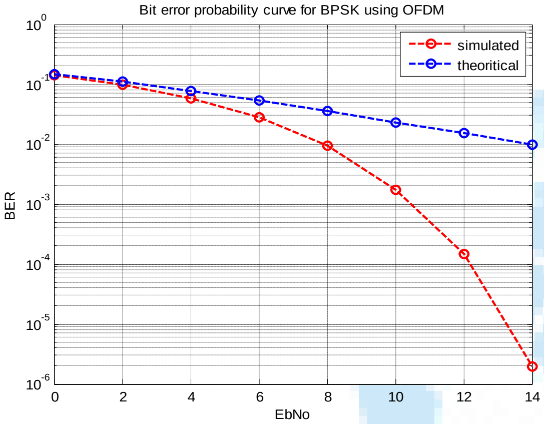

Fig.(5).BER probability for BPSK

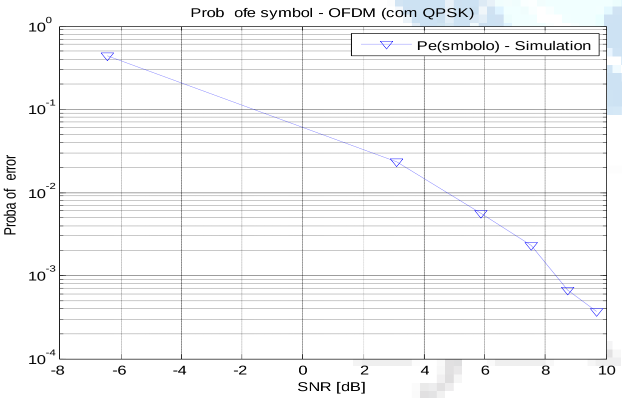

Fig.(6). BER probability of QPSK

Theoretical BER values for BPSK and QAM:

0.1464	0.1085	0.0771	0.0530	0.0355
0.1392	0.0976	0.0586	0.0279	0.0092

Table-1. Theoretical BER values for QPSK and QAM

Channel estimation of CP OFDM:

The result of channel estimation is affected by the SNR value. The larger the SNR the higher accuracy of the estimation will be. It relates to the selection of channel estimation and detection techniques. The estimation results also affect the value of BER that would be decrease by increasing the value of SNR.

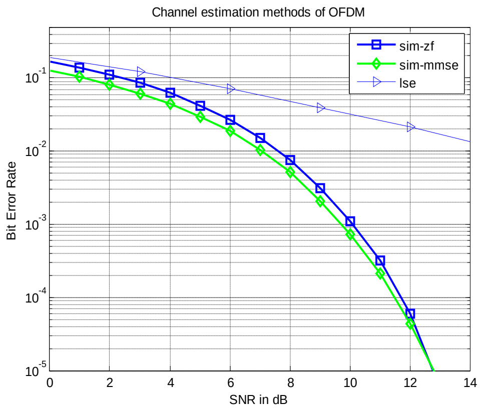

Fig.(7).Channel estimation methods of OFDM

Energy Efficient Binary Power Control:

Based on the system models, we will now evaluate the proposed EBPCB algorithm performance in MIMO-OFDM wireless communication systems through Monte Carlo simulations. The radius of the single-cell is ranged from 300 to 500m and the protection distance *d* is assumed as 50m. Further simulation details are configured as follows: the system bandwidth is assumed as 1 MHz; the bit rate is assumed as 10kb/s in all sub channels for simplicity; the BER upper bound is configured as 10−11% the total transmission power of the base station is ranged from 0.6 to 1.4 watt (W); the path loss coefficient is ranged from 3.8 to 4.1.

Considering the OFDM scheme used in MIMO wireless communication systems, the number of sub channels is ranged from 8 to 128; the AWGN *n*0 is configured as 0.1W This result demonstrates the effect of energy efficiency optimization by optimal power allocation. For EBPCB and EBPC, the curves show that the energy efficiency of these two schemes. For when the number of sub channels is less than 32.

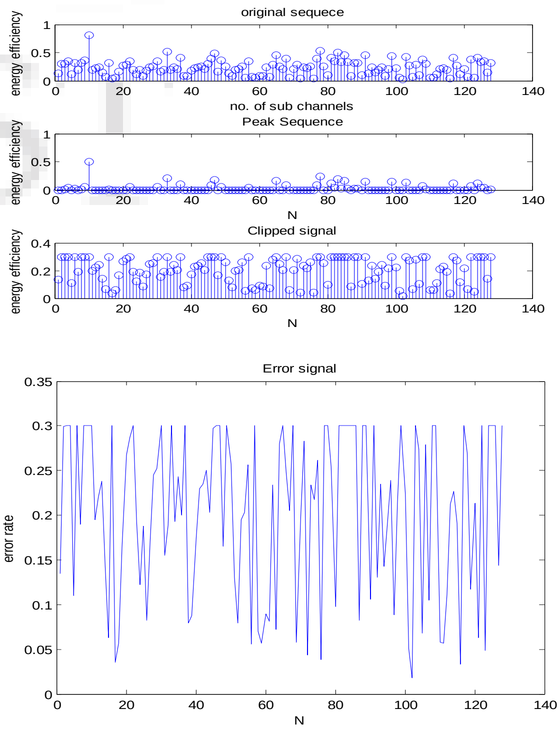

Fig.(8).Binary power estimation using EBPCB algorithm along with error signal

VI. FUTURE WORK

OFDM modulation is a very flexible transmission technique. It has a broad range of uses of which there are some applications already in commercial use. This project only covers a small amount of issues that affect the modulation scheme.

For the future work, the following areas could be further studied:

- The use of Simulink for simulation of radio environment
- RF stage to be added for fully complement in the transmission stage
- Consider the impact of current mobility issues, such as the speed of a vehicle moving, would have on OFDM as a wireless and mobile communication system
- Research the implications on security and how various levels of security can be utilized.

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